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Surplus Labor in Indian Manufacturing: Evidence from the Annual Survey of Industries

Subhash C. Ray
University of Connecticut

Anasua Bhattacharya

University of Connecticut

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Subhash Ray
University of Connecticut

Anasua Bhattacharya
University of Connecticut

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341 Mansfield Road, Unit 1063
Storrs, CT 06269–1063
Phone: (860) 486–3022
Fax: (860) 486–4463
http://www.econ.uconn.edu/

Abstract

In this paper we analyze state level data for total manufacturing constructed from the Annual Survey of Industries for the period 1986-2000 using the non-parametric method of Data Envelopment Analysis (DEA). We assess the extent of surplus labor in the manufacturing sector in the individual states in India. The study also investigates whether the same states show the maximum incidence of surplus labor every year in the sample period and if there any evidence that the extent of surplus labor in manufacturing has been reduced or eliminated in the post-reform era. Our study shows the presence of considerable measure of surplus labor in all of the years in a majority of the states. Things have worsened rather than improved after the reform. Also, the regional distribution of surplus labor has remain fairly unchanged with the same states performing inefficiently both before and after the reform.

SURPLUS LABOR IN INDIAN MANUFACTURING:
EVIDENCE FROM THE ANNUAL SURVEY OF INDUSTRIES

In a Lewis-type dual economy model, existence of surplus labor is typically associated with the backward or traditional sector consisting mainly of subsistence farms where the wage rate equals the average productivity of labor. It is argued that withdrawal of labor will have no impact on the level of output in such farms either because the marginal productivity of labor is zero or because the remaining workers can make up for the lost labor input by working more intensively (Sen 1966). By contrast, the advanced or modern sector consists of profit-maximizing manufacturing firms where the level of employment of any input is determined by the equality of its price with the value of its marginal product. It seems counter-intuitive, therefore, to talk about the possible presence of surplus labor in manufacturing. There can be several reasons, however, why one may find surplus labor in the manufacturing sector in India. First, in the public sector units, the profit motive is attenuated by the fact that the management is not strictly accountable to any clearly identifiable body of owners. In the private sector, on the other hand, severe government regulation effectively imposes a rate of return restriction and the management has limited incentives to reduce employment to contain cost. Second, due to militant trade unionism in the manufacturing sector, any significant retrenchment of its workforce puts the firm at a risk of severe labor unrest the cost of which can easily neutralize any cost saving from a lower level of employment. Firms may, therefore, continue to employ excessive number of workers as the lesser of two evils. Finally, in a poor country like India, providing employment to more people is one of the objectives of economic policy of the government and firms in both the public and the private sectors are under pressure to avoid retrenchment of workers. It is believed, however, that following the economic reforms introduced in 1991 and the subsequent years, the manufacturing firms have gained greater flexibility than before to respond to the market incentives. Hence, in the post-reform years there should be no evidence of surplus labor remaining in manufacturing[1].

In several of the Indian states, especially West Bengal and Kerala, the state government has been in the hands of the Communist parties and their allies. It is often argued that the pro-labor and anti-business broadsides of the government in these states often create a culture of widespread shirking on the job. With hardly any disciplinary options before them, firms make no major new investment in these states and tend to move out in the long run. In the popular perception, this is the principal factor behind the industrial stagnation in the state of West Bengal.

In this paper we analyze state level data[2] for total manufacturing constructed from the Annual Survey of Industries for the period 1986-2000 using the nonparametric method of Data Envelopment Analysis (DEA). We address the following questions:

- What is the extent of surplus labor in the manufacturing sector in the individual states in India?

[1] For an analysis of the effects of the reforms on productivity growth in Indian manufacturing see Ray (2002).

- Do the same states show the maximum incidence of surplus labor every year in the sample period?
- Is there any evidence to suggest that the extent of surplus labor in manufacturing has been reduced or eliminated in the post-reform era?

The rest of the paper is organized as follows. In section 2, we briefly describe the DEA methodology and the various linear programming (LP) models that need to be solved to obtain various measures of surplus labor from the data. Section 3 describes the application to Indian manufacturing. The empirical findings of the study are presented in section 4. Section 5 summarizes the main conclusions of this paper.

2. The Nonparametric Methodology:

In most empirical applications of productivity and efficiency analysis, some explicit functional form of a production, cost, or profit function (e.g., the Cobb Douglas) is specified and the parameters of the model are estimated by appropriate econometric methods. Validity of results derived from the analysis, naturally, depends on the appropriateness of the functional form specified. The mathematical programming method of Data Envelopment Analysis (DEA) introduced by Charnes, Cooper, and Rhodes (CCR) (1978) and subsequently generalized for variable returns to scale technologies by Banker, Charnes, and Cooper (BCC) (1984) provides a nonparametric alternative to econometric modeling[3]. In DEA one makes the following general assumptions about the production technology without specifying any functional form. These are fairly weak assumptions and hold for all technologies represented by a quasi-concave and weakly monotonic production function.

(A1) All actually observed input-output combinations are feasible. An input-output bundle (x, y) is feasible when the output bundle y can be produced from the input bundle x. Suppose that we have a sample of N firms from an industry producing m outputs from n inputs. Let $x^j = (x_{1j}, x_{2j}, \ldots, x_{nj})$ be the input bundle of firm j $(j = 1,2,\ldots,N)$ and $y^j = (y_{1j}, y_{2j}, \ldots, y_{mj})$ be its observed output bundle. Then, by (A1) each (x^j, y^j) $(j = 1,2,\ldots, N)$ is a feasible input-output bundle.

(A2) The production possibility set is convex. Consider two feasible input-output bundles (x^A, y^A) and (x^B, y^B). Then the (weighted) average input-output bundle $(\bar{x}, \bar{y})$, where $\bar{x} = \lambda x^A + (1-\lambda)x^B$ and $\bar{y} = \lambda y^A + (1-\lambda)y^B$ for any λ satisfying $0 \le \lambda \le 1$, is also feasible.

(A3) Inputs are freely disposable. If (x^0, y^0) is feasible, then for any $x \ge x^0$, (x, y^0) is also feasible.

(A4) Outputs are freely disposable. If (x^0, y^0) is feasible, then for any $y \le y^0$, (x^0, y) is also feasible.

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[2] Definition of a "state" in the present context is broad enough to include some union territories.
[3] For a detailed exposition of the method of Data Envelopment Analysis, see Ray (2003).

It is possible to empirically construct a production possibility set satisfying assumptions (A1-A4) from the observed data without any explicit specification of a production function. Consider the input-output pair $(\hat{x}, \hat{y})$ where $\hat{x} = \sum_1^N \mu_j x^j$, $\hat{y} = \sum_1^N \mu_j y^j$, $\sum_1^N \mu_j = 1$, and $\mu_j \geq 0; (j = 1,2,..., N)$. By (A1-A2), $(\hat{x}, \hat{y})$ is feasible.

Now, by (A3), if $x \geq \hat{x}, (x, \hat{y})$ is also feasibly. Next, by (A4), if $y \leq \hat{y}, (x, y)$ is feasible. Thus, using (A1-A4), we can construct the production possibility set:

$$S^V = \{(x, y) : x \geq \sum_1^N \mu_j x^j ; y \leq \sum_1^N \mu_j y^j ; \sum_1^N \mu_j = 1; \mu_j \geq 0 (j = 1,2..., N)\}. \quad (1)$$

Varian (1984) calls S^V an inner approximation to the true production possibility set satisfying (A1-A4).

If additionally we assume that constant returns to scale holds,

(A5) If *(x, y)* is feasible, then for any $k \geq 0$, (kx, ky) is also feasible.

Consider some $(x, y) \in S^V$. Define $\tilde{x} = kx$ and $\tilde{y} = ky$ for some $k \geq 0$. Then $\sum_1^N \tilde{y} \leq k \sum_1^N \mu_j y^j$ and $\tilde{x} \geq k \sum_1^N \mu_j x^j$ .Define $\lambda_j = k\mu_j$. Then $\lambda_j \geq 0$ and $\sum_1^N \lambda_j = k$. But *k* is only restricted to be non-negative. Hence, beyond non-negativity, there are no additional restrictions on the λ_j s. Thus, if we assume constant returns, then the production possibility set becomes

$$S^C = \{(x, y) : x \geq \sum_1^N \lambda_j x^j ; y \leq \sum_1^N \lambda_j y^j ; \lambda \geq 0 (j = 1,2,..., N)\}. \quad (2)$$

An alternative representation of the production possibility set is possible in terms of the input requirement sets. For any output bundle *y* the input requirement set is

$V(y) = \{ x: x \text{ can produce } y \}$. *(3)*

The following properties of input sets follow from the assumptions made about the production possibility set.

(V1) If (x^j, y^j) is an actually observed input-output combination, then $x^j \in V(y^j)$.

Clearly, every observed $(x^j, y^j) \in T$. Hence, by definition of an input set, $x^j \in V(y^j)$.

(V2) If $x^0 \in V(y^0)$ and $x^1 \geq x^0$, then $x^0 \in V(y^0)$.

This follows from the assumption of free disposability of inputs. Because $(x^1, y^0) \in T$, whenever $x^1 \geq x^0$ and $(x^0, y^0) \in T$, (V2) follows. Varian (1984) calls this the monotonicity property of input sets.

(V3) If $x^0 \in V(y^0)$ and $y^1 \leq y^0$, then $x^1 \in V(y^1)$.

This follows from the assumption of free disposability of outputs. Because $(x^0, y^1) \in T$, whenever $y^1 \leq y^0$ and $(x^0, y^0) \in T$, (V3) follows. Varian (1984) calls this the "nestedness" property of input sets. This implies that the input set of a larger output bundle is a subset of the input set of a smaller output bundle.

(V4) Each input set $V(y)$ is convex.

Convexity of the production possibility set is sufficient, but not necessary, for the convexity of input sets. Consider two different input bundle x^0 and x^1 such that $(x^0, y^0) \in T$ and that $(x^1, y^0) \in T$. Let $\bar{x} = \lambda x^0 + (1-\lambda)x^1$, where $0 < \lambda < 1$. Then, by convexity of T, $(\bar{x}, y^0) \in T$. That, of course, implies that. $\bar{x} \in V(y^0)$. It should be noted, however, that the input set will be convex whenever the production function is quasi-concave. But a quasi-concave production function may quite easily correspond to a non-convex production possibility set.

The input-oriented radial measure of technical efficiency of a firm producing output y^0 from the input bundle x^0 is θ^*. where

$$\theta^* = \min \theta : \theta x^0 \in V(y^0). \qquad (4)$$

The BCC- DEA LP problem for measuring the input-oriented technical efficiency is:

$$\begin{aligned} & \min \ \theta \\ \text{s. t.} \quad & \sum_1^N \lambda_j y^j \geq y^0; \\ & \sum_1^N \lambda_j x^j \leq \theta x^0; \qquad (5) \\ & \sum_1^N \lambda_j = 1; \\ & \lambda_j \geq 0; (j = 1,2,\ldots,N). \end{aligned}$$

The standard BCC model measures the potential for equi-proportionate reduction in *all* inputs. In some cases, the primary interest would be in reducing some inputs to the maximum extent possible with the restriction that the remaining inputs are not to be increased beyond their observed level. Suppose that the input vector x is partitioned as $x = (L, K)$ and technical inefficiency of a firm is to be measured by the extent to which it is possible to scale down the sub-vector of inputs L. In this case it is useful to define the conditional input requirement set

$$V(y^0 \mid K^0) = \{ L: (L, K^0) \in V(y^0)\}. \qquad (6)$$

It includes all bundles L that, in conjunction with the other inputs K^0 , can produce the output y^0. The sub-vector (input) efficiency of a firm producing y^0 from the input bundle (L^0, K^0) is

θ^*_L = min θ_L: $\theta_L L^0 \in V(y^0 \mid K^0)$. (7)

The following properties of the conditional input requirement sets follow from the basic assumptions (A1-A4) about the technology:

(B1) $L^j \in V(y^j \mid K^j)$ for each observed input-output bundle (L^j, K^j, y^j) $(j = 1,2,\ldots,N)$.

(B2) $V(y \mid K)$ is a convex set.

(B3) If $L^0 \in V(y \mid K)$ and $L^1 \geq L^0$, then $L^1 \in V(y \mid K)$.

(B4) If $L^0 \in V(y^0 \mid K)$ and $y^1 \leq y^0$, then $L^0 \in V(y^1 \mid K)$.

(B5) If $L^0 \in V(y \mid K^0)$ and $K^1 \geq K^0$, then $L^0 \in V(y \mid K^1)$.

The relevant BCC-type DEA model for measuring sub-vector (input) efficiency is

$$
\begin{aligned}
& \theta^*_L = \min \ \theta \\
\text{s. t.} \quad & \sum_1^N \lambda_j y^j \geq y^0; \\
& \sum_1^N \lambda_j L^j \leq \theta L^0; \\
& \sum_1^N \lambda_j K^j \leq K^0; \\
& \sum_1^N \lambda_j = 1; \\
& \lambda_j \geq 0; (j = 1,2,\ldots,N).
\end{aligned}
\tag{8}
$$

Recall that the standard BCC-DEA model radially projects an observed input bundle x^0 onto the efficient frontier of the input requirement set of the output y^0. When input price vector (w^0) is available and if cost-minimization is a valid criterion for evaluating efficiency, one needs to solve the BCC (cost) DEA problem:

$$
\begin{aligned}
& \min \ w^{0\prime} x \\
\text{subject to} \quad & \sum_1^N \lambda_j y^j \geq y^0; \\
& \sum_1^N \lambda_j x^j \leq x;
\end{aligned}
\tag{9}
$$

$$\sum_{1}^{N} \lambda_j = 1;$$

$$\lambda_j \geq 0; (j = 1,2,...,N).$$

Comparison of the actual input bundle x^0 with the optimal input bundle x^* reveals whether the firm is using too little or too much of any specific input in the overall bundle.

When the focus is on the input sub-vector L, one can use the associated input price vector w^0_L solve the partial cost-minimization problem:

$$\min \; w_L^{0}{}'L$$

$$\text{s. t.} \quad \sum_{1}^{N} \lambda_j y^j \geq y^0;$$

$$\sum_{1}^{N} \lambda_j L^j \leq L;$$

$$\sum_{1}^{N} \lambda_j K^j \leq K^0; \qquad (10)$$

$$\sum_{1}^{N} \lambda_j = 1;$$

$$\lambda_j \geq 0; (j = 1,2,...,N).$$

Here, again, one can use the difference between the actual cost $(w_L^{0}{}'L^0)$ and the optimal cost $(w_L^{0}{}'L^*)$ as a comprehensive measure of the excessive use of the inputs L.

3. The Application to Indian Manufacturing

We conceptualize a single-output, 5-input production technology for the total manufacturing sector in India. Output is measured by the gross value of production consisting of the value of shipments and change in the inventories of finished goods. The inputs include (i) production workers, (L_1) (ii) non-production workers (L_2),(iii) capital (K), (iv) fuels (F), and (v) materials (M). The objective of the study is to measure the sub-vector input efficiency and the degree of excessive use of the labor inputs $(L_1$ and $L_2)$. For this we consider a number alternative DEA models.

The first is a radial input-oriented BCC-DEA model for sub-vector efficiency:

$$\min \; \theta$$

$$\sum_{j1}^{N} \lambda_j y^j \geq y^0; \quad \text{(output)}$$

$$\sum_{j} \lambda_j L_{ij} \leq \theta L_{10} \quad \text{(production labor);}$$

$$\sum_{j} \lambda_j L_{2j} \leq \theta L_{20} \text{ (non-production labor);} \qquad (11)$$

$$\sum_j \lambda_j K_j \leq K_0 \quad \text{(capital);}$$
$$\sum_j \lambda_j F_j \leq F_0 \quad \text{(fuels)}$$
$$\sum_j \lambda_j M_j \leq M_0 \quad \text{(materials)}$$
$$\sum_1^N \lambda_j = 1;\ \lambda_j \geq 0; (j = 1,2,..., N).$$

When the optimal value θ^* is less than unity, $(1-\theta^*)$ shows that the proportion of surplus labor that exists in both types of employment. In fact, when there is any input slack in any one kind of labor, there is even greater proportion of surplus in that type of manpower in the firm.

An alternative way to measure the incidence of surplus labor is to compare the actual wage bill of a firm with the minimum labor cost that must be incurred in order to produce its observed level of output without increasing any of its non-labor inputs. For this we need to solve the following optimization problem:

$$\min \ w_1^0 L_1 + w_2^0 L_2$$

$$\text{s. t.} \quad \sum_j^N \lambda_j y^j \geq y^0; \quad \text{(output)}$$
$$\sum_j^N \lambda_j L_{1j} \leq L_1; \quad \text{(production labor)}$$
$$\sum_j^N \lambda_j L_{2j} \leq L_2; \quad \text{(non-production labor)} \qquad (12)$$
$$\sum_j \lambda_j K_j \leq K_0 \quad \text{(capital);}$$
$$\sum_j \lambda_j F_j \leq F_0 \quad \text{(fuels)}$$
$$\sum_j \lambda_j M_j \leq M_0 \quad \text{(materials)}$$
$$\sum_1^N \lambda_j = 1;\ \lambda_j \geq 0; (j = 1,2,..., N).$$

Note that while the total cost of the optimal employment (L_1^*, L_2^*) will be lower than the cost of the observed employment (L_1^0, L_2^0), the optimal quantity of any one kind of labor may in fact be higher than the quantity actually employed by the firm. That is, the firm may be using too little production or non-production workers even though there is an excess of labor overall.

In this partial cost-minimization problem the two different kinds of labor are weighted by their respective wage rates. Because non-production labor typically earns a higher wage rate, reduction of the managerial or white collar workforce by one employee carries greater weight than a similar downsizing of the production workforce. Often it is interesting to examine the extent of surplus in the total employment without differentiating between blue-collar and white-collar workers. This amounts to setting the wage rates of both kinds of workers equal to unity in the above problem and minimizing the total employment. In this sense it is a special case of the cost-minimization problem. Note that even here, minimizing total employment can be quite consistent with increasing one kind of employment while reducing the other.

(Figure 1 approximately here)

The various efficiency measures are illustrated diagrammatically in Figure 1. The broken line ABCDE shows the frontier of the conditional input requirement set $V(y_0|K^0)$ for the output level y_0 and the quasi-fixed input bundle $K^{0.}$. Points on or above this line show combinations of the variable inputs (the two kinds of labor, L_1 and L_2) all of which can produce the output y_0 when combined with the quasi-fixed inputs K^0. The point L^0 shows the combination of the two types of labor inputs (L^0_1 and L^0_2) that a firm is observed using to produce output y_0 from K_0 . The radial projection of this point on to the frontier is the point F representing the input bundle (L^*_1, L^*_2). Thus the radial labor efficiency of this firm is $\theta_L = \frac{OF}{OL^0}$. It is possible to scale down both of the labor inputs by this factor without reducing the output or increasing any of the quasi-fixed inputs. Note that one could reduce input L_1 even further by moving to the point D on this frontier. The line *MN* with slope equal to –1 shows combinations of the two types of labor inputs all of which result in the same level of total employment. Point C on the frontier shows the labor bundle that produces y_0 from K^0 with the minimum level of *total* employment. Two points may be noted. First, the optimal point C represents a smaller number of type 1 workers but a higher number of type 2 workers. This substitution between the two types of workers results in a reduction of total employment. Second, because the points C and G both lie on the line MN and represent the same level of total employment, we can measure the total labor efficiency of the firm by the ratio $\theta^T_L = \frac{OG}{OL^0}$. Because no point in the set $V(y_0|K^0)$ represents a lower level of total employment, $\theta^T_L \leq \theta_L$. Finally, all points on the line RS represent combinations of the two types of labor that lead to the same wage bill. Point B represents the combination (L^C_1, L^C_2) that minimizes the total labor cost for output y_0 from quasi-fixed input K^0 at wage rates (w^0_1, w^0_2). The point H on the line RS shows a combination of the two kinds of labor that costs the same amount as the bundle B. Thus, the labor cost efficiency of the firm is $\theta^C_L = \frac{OH}{OL^0}$. Whether the point H lies to the left or to the right of the point G on the line OL^0 will depend on the slope of the line RS (i.e., the ratio of the wage rates of the two kinds of labor). Even when the point C is the optimal point for both minimizing total employment and the total labor cost, the two efficiency measures will be different (except when the two kinds of labor have the same wage rate).

In this paper, we examine state-level data from India for the years 1986-87 through 1999-2000. The period up to 1990-91 is regarded as "pre-reform" and the subsequent period in the sample is regarded as "post-reform". The data for different states come from the Annual Survey of Industries (ASI) for the relevant years. In light of inter-state differences in the output-mix, use of gross value to measure output may appear problematic. However, as shown in Ray (2002), under the assumption of identical output prices for different kinds of manufactured products across the nation, the value of aggregate output in manufacturing can serve as a quantity index of output.

Labor inputs - both production and non-production workers - are measured by numbers of persons employed. The energy input was measured by expenses on fuels deflated by the fuel, power, and lubricant price index with 1981-82 as the base year. Similarly, the material input was measured by the cost of materials deflated by the industrial raw materials price index.

Measuring the capital input is especially problematic. It may be treated either as stock measured by the book value of fixed assets or as a flow measured by the sum of rent, repairs, and depreciation expenses. The former is vulnerable on two counts. First, the book value may correlate poorly with the physical stock of machinery and equipment. Second, the capacity may not be fully utilized. The flow measure, on the other hand, may be questioned on the ground that the depreciation charges in the financial accounts may be unrelated to actual wear and tear of the hardware. People have, in some cases, used a perpetual inventory method to construct a capital stock series from annual investment data. That does not address the question of capacity utilization, however. In this paper, capital was measured as stock by the book value of fixed assets deflated by the price index of new capital equipment with 1981-82 as the base. This, clearly, is an imperfect measure. But, to the extent that the true capital input is distorted in a uniform manner for all states, their relative performance should not be affected seriously by this shortcoming.

A more serious problem that applies to all non-labor inputs is that no information on inter-state variation on prices was available. It was necessary, therefore, to apply the all-India price indexes as deflators for all states in any individual year.

4. The Empirical Findings

Tables 1a-1b report the radial measures of labor efficiency for each state for the different years in the sample period. A value less than unity in any year for a specific state implies that it would be possible to scale down the level of employment of both categories of labor in that state by that factor without increasing any other input or reducing the level of output. It needs to be emphasized that this radial measure often understates the extent of surplus labor that exists in a given context. For a specific example consider the case of Kerala (KE) in the year 1986-87. The radial labor efficiency in this case is 0.81356. That is, it is possible to reduce the numbers of both production and non-production workers by 18.644%. But this does not exhaust the potential for reducing employment completely. The optimal solution of the relevant LP problem shows a slack of 3.978 units in L_1. That implies that although the number of non-production workers cannot be reduced any further, employment of production workers can be down-sized to about only 75% of the actual level. As is evident from Table 1a, West Bengal (WB) exhibits the highest incidence of surplus labor during the pre-reform years. In deed, except for the year 1987-88, labor efficiency in this state was around 60% or lower in all other years during this period. On average, it would have been possible to reduce both kinds of labor by over 35%. Among the other states, Haryana (HA), Pondicherry (PO), and Uttar Pradesh (UP) also show significant proportions of surplus labor. Table 1b shows that West Bengal (WB) continued to employ surplus labor over the post-reform years. In fact, the radial labor efficiency declined further. During this period the average proportion of surplus labor increased to over 46%. Two other states – Karnataka (KA) and Punjab (PU) – joined Haryana (HA) in the bracket with labor efficiency between 0.75 and 0.80. On the other hand, Pondicherry (PO) showed considerable decline in the proportion of surplus labor in the post-reform years. Also, rather interestingly, the number of states with no evidence of surplus labor declined from 8 to 4. Only Bihar (BI), Chandigarh (CH), Delhi (DE), and Goa (GO) were found to operate at full labor efficiency in both periods.

The radial measure of labor efficiency does not consider the possibility of substitution between the two different categories of labor. Tables 2a-2b show the levels of total labor efficiency measured by the ratio of the minimum to the actual level of total employment. Note that in this approach, we allow increase in one category of employment so long as the total employment is minimized without requiring any non-labor input to increase or the output to decline. The column labeled LEFF show the total labor efficiency of any state in a given year. The other columns L1EFF and L2EFF show the ratio of the optimal and the actual levels of employment of production and non-production workers, respectively. A value less than unity implies that the optimal is less than the actual number and too many workers of a particular category are being employed. By contrast, a value greater than 1 implies that too few workers of that category are being used and employment of this specific type should actually be increased. Tables 2a-2b portray a drastically different picture than Tables 1a-1b. First, the measured levels of total labor efficiency (θ^T_L) are, in general, much lower than the corresponding radial efficiency measures. This is revealed most dramatically in the case of Kerala (KE) where the post reform average of radial efficiency was 0.94 while the corresponding total labor efficiency was a mere 0.63. That means that if we want to *reduce both kinds of labor by the same proportion* only a 6% reduction would be possible. But, if we looked for *a reduction in total employment*, a 37% reduction would be feasible without reducing output or requiring any increase in the quasi-fixed inputs. In fact, the entries in the columns for L1EFF and L2EFF reveal that a 2.6% increase in the number of non-production workers (L_2) would permit a 45.2% decline in the employment of production workers leading to a 37% reduction in total employment. Consider the year 1999-2000. The radial measure for Kerala shows that it is not possible at all to reduce *both types of employment.* This results in a 100% measure of θ_L as shown for the relevant year in Table 1b. Table 2b shows, however, that one could reduce the employment of production workers by 53.4% at the expense of a 31% increase in the number of non-production workers. This would reduce total employment by more than 40%. Five states (Assam(AS), Bihar (BI), Gujarat (GU), Kerala (KE), and Tamilnadu (TN)) show average values of L2EFF greater than unity. This implies that they are using less than the optimal number of non-production workers on average in both the pre-reform and the post-reform years. Andhra Pradesh (AP) is using too few non-production workers in the post-reform period. There is ample evidence of surplus labor in respect of production workers in both the pre-reform and the post-reform years. There was surplus of production labor in excess of 20% in 6 states (Haryana (HA), Kerala (KE), Punjab (PU), Uttar Pradesh (UP), West Bengal (WB), and Pondicherry (PO)) in the pre-reform years. All of these states and, additionally, Assam (AS), Karnataka (KA), and Tamilnadu (TN) exhibit surplus of production of labor in excess of 20% in the post-reform years as well. West Bengal (WB) showed production labor efficiency as low as 57.6% in the pre-reform years and 41.7% in the post-reform years. For the country as a whole, there is no evidence of any overall improvement in labor efficiency in the years after the reforms.

Finally, consider the labor cost efficiencies reported in Tables 3a-3b. The labor cost efficiency compares the minimum labor cost with the cost of the actual level of employment. Because the wage rate of non-production workers is higher than the wage rate of production workers, levels of labor cost efficiency are, in general, higher than the total labor efficiency levels reported in Tables 2a-2b. But even by this measure, there is considerable inefficiency in labor use. In the pre-reform years there was potential for reducing the labor cost by more than 20% in Haryana (HA), Uttar Pradesh (UP), West Bengal (WB), and Pondicherry (PO).In the post-reform years, Assam (AS), Karnataka (KA), Kerala (KE), and Punjab (PU) also joined this group. In 13 of the 22 states in the sample, labor cost efficiency declined after the reforms. Assam (AS) and Karanataka (KA) saw a decline by about 20 percentage points followed by Kerala (KE) and West Bengal (WB) where cost efficiency declined by about 13 percentage points. This is particularly alarming in the case of West Bengal (WB) where cost efficiency was a low 60% to start with, has been consistently below 50% very year since 1993-94, and dipped to as low as 35.8% in 1998-99.

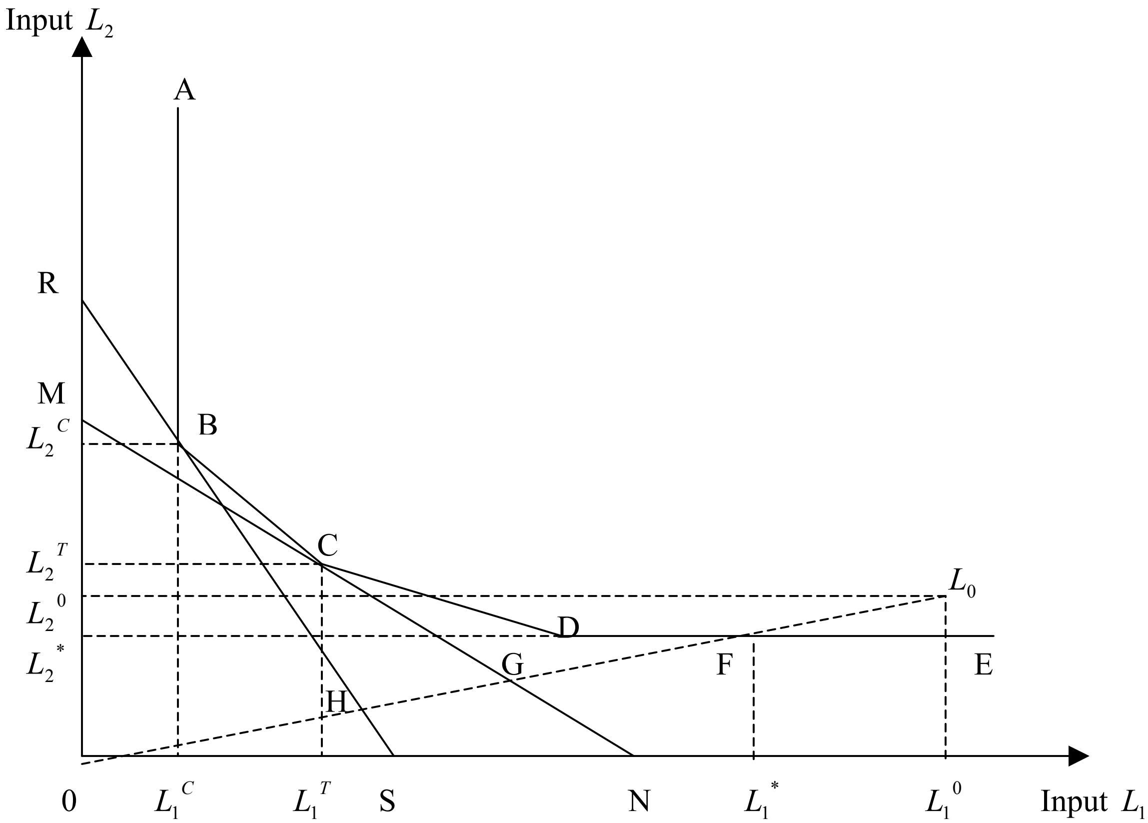
The low levels of labor use efficiency in the Communist–dominated states of West Bengal (WB) and Kerala (KE) are, in a way, not surprising. In the case of Assam (AS) the post-reform decline in efficiency is probably due to the deteriorating law and order condition in the state. Surprisingly, no such evidence is found in the case of Jammu and Kashmir (JK). Several states have consistently performed at 100% efficiency throughout the years covered in this study. They include Chandigarh (CH), Delhi (DE), and Goa (GO). Several other states (Bihar (BI), Himachal Pradesh (HP), Maharashtra (MH), and Anadaman and Nicobar (AN)) also performed efficiently except in some odd years (e.g., Andaman-Nicobar (AN) in 1993-94, and Himachal Pradesh (HP) in 1997-98).

The widespread evidence of surplus labor amongst production workers in most years is quite puzzling. A possible explanation is that shortage of critical inputs like energy coupled with inadequate transportation and other infra-structural facilities resulted in frequent down-time in the plants. At the same time political pressure from the trade unions as well as from the government stood in the way of temporarily laying off the surplus workers. This, of course, is a matter of speculation at this point and should be verified from statistics of man days lost.

Finally, the empirical analysis does not show that the incidence of surplus labor has declined after the reforms. If anything, the situation appears to have become worse. Also, overall, there is a persistence in the regional pattern in the existence of surplus labor. States with low levels of labor efficiency have generally remained inefficient while those with a record of better utilization of labor have generally out-performed others in most years.

5. Summary and Conclusions:

It is widely believed that years of government regulation on the one hand and militant trade unionism on the other has created an industrial climate in India where a significant part of the labor force actually employed is dispensable. It is also assumed that the economic reforms will enable the firms to appropriately down-size employment in order to survive in an increasingly competitive market. We have used the nonparametric method of Data Envelopment Analysis (DEA) to assess the validity of these hypotheses. The empirical analysis based on state level data from the Annual Survey of Industries for the years 1986-87 through 1999-2000 does show that there is a considerable measure of surplus labor in Indian manufacturing. Some states (like West Bengal (WB) and Kerala (KE)) are found to have been operating at very low levels of labor use efficiency. There is no evidence showing an overall improvement in labor efficiency in the post-reform years. Also, the regional pattern of inefficiency has remained fairly stable.



Input L_2
A
R
M
L_2^C
B
C
L_2^T
L_0
L_2^0
D
L_2^*
G
F
E
H
0
L_1^C
L_1^T
S
N
L_1^*
L_1^0
Input L_1

Figure 1

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Table 1a. Radial Labor Efficiency: Pre-Reform Years

State	8687	8788	8889	8990	9091	Avg Yrs
AP	1	1	1	1	1	**1**
AS	1	1	0.88212	1	1	**0.976424**
BI	1	1	1	1	1	**1**
GU	1	1	1	0.95571	1	**0.991142**
HA	0.743	0.74018	0.78221	0.80848	0.83042	**0.780858**
HP	1	1	1	1	1	**1**
JK	0.69052	1	0.76256	0.94474	1	**0.879564**
KA	1	1	1	1	0.77943	**0.955886**
KE	0.81356	1	0.84127	1	0.9244	**0.915846**
MP	1	1	1	0.88309	0.8591	**0.948438**
MH	1	1	1	1	1	**1**
OR	0.93364	0.81063	1	1	0.86223	**0.9213**
PU	0.93424	0.89848	0.83635	0.90857	0.85447	**0.886422**
RA	1	0.76186	0.8441	0.80802	0.86595	**0.855986**
TN	0.9623	0.88211	0.97055	1	0.94494	**0.95198**
UP	0.84438	0.78679	0.78957	0.85189	0.86692	**0.82791**
WB	0.60463	1	0.53804	0.52707	0.55554	**0.645056**
AN	1	1	1	1	1	**1**
CH	1	1	1	1	1	**1**
DE	1	1	1	1	1	**1**
GO	1	1	1	1	1	**1**
PO	1	0.72829	0.72724	0.69947	0.74507	**0.780014**

Table 1b. Radial Labor Efficiency: Post-Reform Years

State	9192	9293	9394	9495	9596	9697	9798	9899
AP	1	1	1	1	1	1	1	0.74862
AS	1	1	0.84559	0.7969	0.84248	0.75432	1	1
BI	1	1	1	1	1	1	1	1
GU	0.90975	1	0.87415	0.95678	0.91846	1	1	0.98809
HA	0.73942	0.68472	0.59853	0.63005	0.6212	1	0.8054	1
HP	1	1	1	1	1	1	0.55432	1
JK	1	1	1	1	1	1	1	0.66388
KA	1	0.73297	0.67518	0.83166	1	0.674	0.68238	0.69282
KE	0.98458	1	0.74863	1	0.94615	1	0.93213	0.85474
MP	0.85252	1	1	1	1	1	1	0.71269
MH	1	1	1	1	1	1	0.89924	1
OR	1	1	0.71238	1	1	1	0.79011	1
PU	0.80285	0.77662	0.66337	0.73303	0.73491	0.70241	0.71343	0.91584
RA	0.95214	0.95529	0.82217	1	0.98522	1	0.91087	0.8005
TN	1	1	0.99257	1	1	1	0.87409	0.89835
UP	1	0.83731	0.80917	0.95142	0.80686	0.99294	0.86326	0.6749
WB	0.57496	0.56217	0.52645	0.58714	0.55309	0.50878	0.56595	0.48541
AN	1	1	0.31629	1	1	1	1	1
CH	1	1	1	1	1	1	1	1
DE	1	1	1	1	1	1	1	1

GO	1	1	1	1	1	1	1	1
PO	0.75873	0.78184	0.70183	0.73352	0.67908	1	1	1

	9900	**Avg Yrs**
AP	0.77488	**0.947056**
AS	0.92464	**0.907103**
BI	1	**1**
GU	0.9384	**0.953959**
HA	0.74576	**0.758342**
HP	0.92947	**0.942643**
JK	0.82306	**0.942993**
KA	0.66383	**0.772538**
KE	1	**0.940692**
MP	1	**0.95169**
MH	1	**0.988804**
OR	1	**0.944721**
PU	0.86497	**0.767492**
RA	1	**0.936243**
TN	0.91372	**0.964303**
UP	0.7412	**0.853007**
WB	0.49076	**0.539412**
AN	1	**0.924032**
CH	1	**1**
DE	1	**1**
GO	1	**1**
PO	1	**0.850556**

Table 2a Category-wise and Total Labor Efficiency

	8687			8788			8889		
NAME	**l1eff**	**l2eff**	**leff**	**l1eff**	**l2eff**	**leff**	**l1eff**	**l2eff**	**leff**
AP	1	1	1	1	1	1	1	1	1
AS	1	1	1	0.64942	1.04017	0.71663	1	1	1
BI	1	1	1	1	1	1	0.92542	1.17751	0.98159
GU	0.89599	1.32899	0.98698	0.91379	1.16423	0.96748	1	1	1
HA	0.69184	0.77908	0.71341	0.7823	0.78106	0.78198	0.75083	0.71213	0.74139
HP	1	1	1	1	1	1	1	1	1
JK	1	1	1	0.75178	0.76672	0.75531	0.65515	0.69052	0.66398
KA	1	1	1	1	1	1	1	1	1
KE	1	1	1	0.63408	0.90223	0.68857	0.64147	1.06165	0.71917
MP	1	1	1	1	1	1	1	1	1
MH	1	1	1	1	1	1	1	1	1
OR	0.72822	0.96692	0.78398	1	1	1	0.85521	0.99713	0.88855
PU	0.68126	1.00695	0.74792	0.68851	0.96557	0.74627	0.78921	0.98413	0.82928
RA	0.68816	0.93553	0.74361	0.82032	0.88071	0.83486	1	1	1
TN	0.67058	1.06308	0.74794	0.87126	1.00714	0.89832	0.89047	1.08047	0.92863
UP	0.63482	0.96218	0.70157	0.69508	0.91855	0.74125	0.73559	0.95038	0.77721
WB	1	1	1	0.50952	0.59043	0.5274	0.48016	0.613	0.50804
AN	1	1	1	1	1	1	1	1	1
CH	1	1	1	1	1	1	1	1	1
DE	1	1	1	1	1	1	1	1	1
GO	1	1	1	1	1	1	1	1	1
PO	0.73264	0.70163	0.72651	0.60161	0.78188	0.63664	1	1	1

NAME	8990			9091			Pre-Reform (Average of Years)		
	l1eff	**l2eff**	**leff**	**l1eff**	**l2eff**	**leff**	**l1eff**	**l2eff**	**leff**
AP	1	1	1	1	1	1	1	1	1
AS	1	1	1	1	1	1	0.929884	1.008034	0.943326
BI	1	1	1	1	1	1	0.985084	1.035502	0.996318
GU	0.84492	1.11138	0.9047	0.77825	1.09867	0.84661	0.88659	1.140654	0.941154
HA	0.78807	0.85666	0.80529	0.73075	0.8592	0.76175	0.748758	0.797626	0.760764
HP	1	1	1	1	1	1	1	1	1
JK	1	1	1	0.79698	0.94752	0.83077	0.840782	0.880952	0.850012
KA	0.77943	0.77273	0.77765	1.05166	0.70274	0.96084	0.966218	0.895094	0.947698
KE	0.51008	1.08271	0.6019	1	1	1	0.757126	1.009318	0.801928
MP	0.8591	0.63622	0.79006	0.88309	0.66684	0.81741	0.948438	0.860612	0.921494
MH	1	1	1	1	1	1	1	1	1
OR	0.86223	0.83756	0.85639	1	1	1	0.889132	0.960322	0.905784
PU	0.6821	0.93533	0.73849	0.73857	1.04563	0.80484	0.71593	0.987522	0.77336
RA	0.81662	0.89186	0.83541	0.72228	0.87752	0.75891	0.809476	0.917124	0.834558
TN	0.77923	0.99604	0.82343	1	1	1	0.842308	1.029346	0.879664
UP	0.68506	0.96016	0.74404	0.67439	0.999	0.74138	0.684988	0.958054	0.74109
WB	0.44842	0.5947	0.48047	0.44097	0.59544	0.47471	0.575814	0.678714	0.598124
AN	1	1	1	1	1	1	1	1	1
CH	1	1	1	1	1	1	1	1	1
DE	1	1	1	1	1	1	1	1	1

GO	1	1	1	1	1	1	1	1	1
PO	0.53004	0.81025	0.58613	0.56531	0.80941	0.61763	0.68592	0.820634	0.713382

Table 2b

	9192			9293			9394		
Name	**I1eff**	**I2eff**	**Ieff**	**I1eff**	**I2eff**	**Ieff**	**I1eff**	**I2eff**	**Ieff**
AP	1	1	1	1	1	1	1	1	1
AS	0.74836	1.18638	0.82329	0.72882	1.21681	0.80661	0.4372	0.89782	0.51317
BI	1	1	1	1	1	1	1	1	1
GU	0.7478	0.98292	0.80186	0.90176	1.08299	0.94682	0.80811	0.9041	0.83234
HA	0.72336	0.76697	0.73508	0.66971	0.68572	0.6741	0.56509	0.59853	0.57436
HP	1	1	1	1	1	1	1	1	1
JK	1	1	1	1	1	1	1	1	1
KA	1	1	1	0.72304	0.74004	0.72762	0.64149	0.70187	0.6569
KE	0.57015	1.06187	0.6564	0.48549	1.0621	0.57435	0.40542	0.78427	0.47235
MP	0.85252	0.7935	0.83489	1	1	1	1	1	1
MH	1	1	1	1	1	1	1	1	1
OR	1	1	1	1	1	1	0.71238	0.67768	0.70373
PU	0.66563	0.86296	0.71209	0.6688	0.84126	0.7116	0.55273	0.69601	0.58803
RA	0.89762	1.02677	0.93108	0.95529	0.91078	0.94326	0.7972	0.84869	0.81077
TN	1	1	1	1	1	1	0.68001	1.01162	0.74623
UP	0.82927	1.14869	0.90078	0.71374	0.92895	0.76375	0.64036	0.8392	0.68554
WB	0.50054	0.65789	0.53722	0.48479	0.59413	0.50978	0.44739	0.54243	0.46877
AN	1	1	1	1	1	1	0.19892	0.31647	0.22226
CH	1	1	1	1	1	1	1	1	1
DE	1	1	1	1	1	1	1	1	1
GO	1	1	1	1	1	1	1	1	1
PO	0.5514	0.82586	0.60786	0.58536	0.80584	0.63427	0.55763	0.71726	0.59329

	9495			9596			9697		
	I1eff	**I2eff**	**Ieff**	**I1eff**	**I2eff**	**Ieff**	**I1eff**	**I2eff**	**Ieff**
AP	1	1	1	1	1	1	1	1	1
AS	0.54208	0.83316	0.59538	0.52594	0.91261	0.59154	0.39736	0.86055	0.47787
BI	1	1	1	1	1	1	1	1	1
GU	0.85099	0.97738	0.88389	0.92314	0.83594	0.89783	1	1	1
HA	0.62429	0.63109	0.62615	0.6212	0.59969	0.61515	1	1	1
HP	1	1	1	1	1	1	1	1	1
JK	1	1	1	1	1	1	1	1	1
KA	0.6664	0.83566	0.70844	1	1	1	0.66327	0.68416	0.66875
KE	1	1	1	0.51824	1.02188	0.60589	0.532	1.02344	0.62668
MP	1	1	1	1	1	1	1	1	1
MH	1	1	1	1	1	1	1	1	1
OR	1	1	1	0.82333	1.01159	0.86618	1	1	1
PU	0.61216	0.77467	0.65276	0.63597	0.78891	0.6741	0.60638	0.75452	0.64432
RA	0.89487	1.02768	0.92948	0.92533	1.02911	0.9522	1	1	1
TN	0.65901	1.11757	0.75079	1	1	1	1	1	1
UP	0.72709	0.97945	0.78535	0.70388	0.89416	0.74802	0.91777	0.99294	0.93544
WB	0.44449	0.61146	0.48151	0.44522	0.6302	0.48421	0.44684	0.55852	0.47257
AN	1	1	1	1	1	1	1	1	1
CH	1	1	1	1	1	1	1	1	1
DE	1	1	1	1	1	1	1	1	1

GO	1	1	1	1	1	1	1	1	1
PO	0.5017	0.77359	0.55611	0.46285	0.72421	0.51492	1	1	1

	9798			**9899**			**9900**		
	I1eff	**I2eff**	**Ieff**	**I1eff**	**I2eff**	**Ieff**	**I1eff**	**I2eff**	**Ieff**
AP	0.72557	1.51739	0.84247	0.44815	0.93345	0.53563	0.39894	1.18477	0.51965
AS	1	1	1	1	1	1	0.4133	1.12213	0.52732
BI	1	1	1	0.70499	1.51022	0.85369	0.65392	1.59856	0.82698
GU	0.84771	1.13305	0.92102	0.93243	0.98809	0.94663	0.80319	0.95049	0.84069
HA	0.70675	0.82635	0.74133	1	1	1	0.74576	0.64879	0.71866
HP	0.55432	0.48048	0.53022	1	1	1	0.72559	0.93509	0.77326
JK	1	1	1	0.43483	0.67152	0.48897	0.44332	0.82499	0.53216
KA	0.51863	0.72515	0.57053	0.60941	0.69282	0.63094	0.50088	0.68087	0.5459
KE	0.46106	1.01324	0.56093	0.49537	0.95508	0.58111	0.46424	1.3152	0.59189
MP	1	1	1	0.73339	0.57874	0.68765	1	1	1
MH	0.85542	0.91379	0.87261	1	1	1	1	1	1
OR	0.69339	0.803	0.71991	1	1	1	1	1	1
PU	0.54739	0.74573	0.5994	0.67165	1.0948	0.76232	0.6599	1.15253	0.76666
RA	0.73619	0.96735	0.79815	0.69582	0.83819	0.73314	0.74542	1.06287	0.82349
TN	0.52596	0.97016	0.61849	0.52872	1.05354	0.62686	0.54503	1.17272	0.66763
UP	0.62987	0.96255	0.70918	0.61363	0.69577	0.63549	0.62832	0.87273	0.68937
WB	0.3412	0.60467	0.39663	0.28957	0.49162	0.32905	0.34909	0.61752	0.40665
AN	1	1	1	1	1	1	1	1	1
CH	1	1	1	1	1	1	1	1	1
DE	1	1	1	1	1	1	1	1	1
GO	1	1	1	1	1	1	1	1	1
PO	1	1	1				1	1	1

	Post-Reform(Average of Years)		
	I1eff	**I2eff**	**Ieff**
AP	0.841407	1.070623	0.877528
AS	0.643673	1.003273	0.703909
BI	0.928768	1.123198	0.964519
GU	0.868348	0.983884	0.896787
HA	0.739573	0.750793	0.742759
HP	0.91999	0.935063	0.922609
JK	0.87535	0.944057	0.891237
KA	0.702569	0.784508	0.723231
KE	0.547997	1.026342	0.629956
MP	0.95399	0.930249	0.946949
MH	0.983936	0.990421	0.985846
OR	0.914344	0.943586	0.921091
PU	0.624512	0.856821	0.679031
RA	0.849749	0.967938	0.880174
TN	0.77097	1.036179	0.823333
UP	0.711548	0.923827	0.761436
WB	0.41657	0.589827	0.454043
AN	0.910991	0.924052	0.913584
CH	1	1	1

DE	1	1	1
GO	1	1	1
PO	0.739882	0.871862	0.767383

Table3a. Labor cost efficiency

NAME	8687	8788	8889	8990	9091	Pre-Reform
AP	1	1	1	1	1	1
AS	1	1	0.7796	1	1	0.95592
BI	1	1	1	1	1	1
GU	1	1	1	0.89324	0.94523	0.96769
HA	0.73552	0.72248	0.78182	0.77819	0.81412	0.76643
HP	1	1	1	1	1	1
JK	0.66939	1	0.75714	0.84686	1	0.85468
KA	1	0.9747	1	0.91163	0.77672	0.93261
KE	0.74474	1	0.7213	1	0.6852	0.83025
MP	1	1	1	0.78819	0.76315	0.91027
MH	1	1	1	1	1	1
OR	0.9068	0.80452	1	1	0.85325	0.91291
PU	0.85264	0.79271	0.78418	0.87659	0.76692	0.81461
RA	1	0.75765	0.84283	0.78261	0.84442	0.8455
TN	0.95952	0.80683	0.91621	1	0.85279	0.90707
UP	0.79859	0.73786	0.76595	0.77901	0.77524	0.77133
WB	0.51903	1	0.53655	0.48767	0.49773	0.6082
AN	1	1	1	1	1	1
CH	1	1	1	1	1	1
DE	1	1	1	1	1	1
GO	1	1	1	1	1	1
PO	1	0.72453	0.65583	0.63	0.60986	0.72404

Table 3b. Labor cost Efficiency

	9192	9293	9394	9495	9596	9697	9798	9899
AP	1	1	1	1	1	1	0.98098	0.6207
AS	0.87946	0.86522	0.57853	0.63565	0.64523	0.53447	1	1
BI	1	1	1	1	1	1	1	0.95123
GU	0.82658	0.97984	0.8507	0.90921	0.88046	1	0.96338	0.95884
HA	0.73699	0.67638	0.57889	0.6271	0.61222	1	0.76395	1
HP	1	1	1	1	1	1	0.51798	1
JK	1	1	1	1	1	1	1	0.51925
KA	1	0.72988	0.66604	0.73341	1	0.67114	0.59173	0.64718
KE	0.72599	0.66431	0.52134	1	0.67951	0.69597	0.63815	0.66063
MP	0.82404	1	1	1	1	1	1	0.66239
MH	1	1	1	1	1	1	0.8801	1
OR	1	1	0.69436	1	0.88841	1	0.73213	1
PU	0.72517	0.74424	0.60219	0.6724	0.69274	0.66287	0.62211	0.79634
RA	0.94807	0.93985	0.82018	0.94875	0.96833	1	0.82758	0.75735
TN	1	1	0.78828	0.82077	1	1	0.68251	0.69708
UP	0.94059	0.7891	0.71641	0.82223	0.76984	0.94676	0.76522	0.65098
WB	0.54585	0.52028	0.47744	0.49706	0.49391	0.48557	0.42297	0.35825
AN	1	1	0.2353	1	1	1	1	1
CH	1	1	1	1	1	1	1	1
DE	1	1	1	1	1	1	1	1

GO	1	1	1	1	1	1	1	1
PO	0.64291	0.66868	0.61317	0.59521	0.55831	1	1	1

	9900	**Post-Reform**
AP	0.65801	0.91774
AS	0.65353	0.75468
BI	0.9584	0.98996
GU	0.87311	0.91579
HA	0.70019	0.74397
HP	0.81526	0.92592
JK	0.62304	0.9047
KA	0.56324	0.73362
KE	0.71385	0.69997
MP	1	0.94294
MH	1	0.98668
OR	1	0.92388
PU	0.84976	0.70754
RA	0.87631	0.89849
TN	0.78062	0.86325
UP	0.74079	0.79355
WB	0.45608	0.47305
AN	1	0.91503
CH	1	1
DE	1	1
GO	1	1
PO	1	0.78648